

THE ANNELIDS OF THE FAMILY ARENICOLIDÆ OF NORTH  
AND SOUTH AMERICA, INCLUDING AN ACCOUNT OF  
ARENICOLA GLACIALIS MURDOCH.

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INTRODUCTION.

The account of the Arenicolidæ which is given in the following pages is based chiefly on material in the U. S. National Museum, to the authorities of which institution I am greatly indebted for their kindness in sending to me for examination the whole collection of specimens belonging to this family of Polychæta. My thanks are also tendered to many others who have helped me with the gift or loan of specimens, and I would mention especially Prof. H. C. Bumpus, Dr. H. P. Johnson, Dr. W. McM. Woodworth, Prof. A. D. Howard, Prof. C. A. Kofoid, Dr. R. S. Lillie, Prof. H. Heath, and Prof. A. L. Treadwell.

In addition to the material received directly from the United States, I have also examined a considerable number of specimens from American sources now deposited in various museums in Europe. I hoped to obtain sufficient material to enable me to give a moderately complete account of the distribution of the American species of *Arenicola*, but, up to the present, the only regions from which material, adequate enough for this purpose, has been obtained are the eastern coast of North America and the extreme south of South America. The stations from which specimens have been taken on the west coast of North and South America are so few that the limits of distribution of the two or three species concerned must be left quite indeterminable, and there are no specimens recorded from the east coast of South America, nor have I been able to obtain any although I have made inquiries for them from several likely sources. It is to be hoped that collections from the west coast of North America and from the seaboard of South America may soon be forthcoming, which will provide the material necessary for the determination of the range of the various species.

## DESCRIPTIONS OF GENUS AND SPECIES.

## Genus ARENICOLA Lamarck.

The characters of this genus may be stated thus: Polychæta, usually found burrowing in sand or gravel, of elongate cylindrical form, provided with pairs of dorsally-borne branched gills which, however, are not present on the first seven segments. Prostomium small, bounded posteriorly by the nuchal groove, without tentacles and palps. Peristomium without cirri. Each chætigerous segment, except the first three or four, is subdivided into five annuli; the annulus which bears the parapodia is larger than the others. Each parapodium consists of a conical notopodium, bearing capillary setæ, and a neuropodium, in the form of a muscular pad or ridge on the lateral or ventro-lateral region of the chætigerous annulus, traversed by a deep groove in which a row of crotchets is situated. The pharynx has no armature except a series of papillæ the tips of which may be capped with chitin. One or more pairs of glandular cœca are present on the posterior part of the œsophagus; a short distance posterior to these is a pair of hearts. The number of nephridia varies in different species, five, six, or thirteen pairs being present; the first nephridium opens on the fourth or fifth segment. Cœlomic septa have disappeared in the region of the body in which the stomach is situated, but septa are constantly present at the anterior border of the first, third, and fourth chætigerous segments and also in a greater or less extent of the intestinal region of the worm. In all the known species, except *A. claparedii* Levinsen, there is a pair of statocysts (otocysts) in the peristomium.

The genus *Arenicola* is divisible into two sections, one, the caudate section, containing those species in which a posterior region or "tail" is present upon which neither parapodia nor gills are borne, the other, the ecaudate section, comprising those species in which the parapodia, and generally also the gills, extend to the posterior end of the animal.

Up to the present no specimen belonging to the ecaudate section of the genus has been recorded from America. The two species, *A. ecaudata* Johnston and *A. grubii* Claparède, which comprise this section, therefore, claim little attention in this communication. It may be stated for the guidance of workers on the American littoral fauna that these two species have hitherto been found, for instance, in Great Britain and France, near low-tide mark and chiefly in coarse gravelly sand, among stones or in débris at the base of rocks formed by the breaking down of the latter. The burrows of these worms are oblique or sinuous cavities in the gravel or between the rocks and the castings of the worms are composed of coarse material, having little coherence, and therefore soon falling to pieces. The well-

known signs, the sand-rope-like castings and the mouth of the burrow, which indicate the presence of *A. marina* on a sandy beach, have no good counterparts in the case of the ecaudate species, in which both the castings and the mouth of the burrow are inconspicuous among their surroundings. Whether these species are present in any given area is therefore not obvious from a superficial examination, as is often the case where *A. marina* is concerned; their presence can only be ascertained after careful, and sometimes prolonged, search in likely places, such as those above suggested.

Four caudate species of *Arenicola* and a variety of one of them are now moderately well known, namely, *A. marina* (Linnaeus), *A. claparedii* Levinsen, *A. assimilis* Ehlers, *A. assimilis*, var. *affinis* Ashworth, and *A. cristata* Stimpson, all of which have been recorded from the shores of North or South America. *A. glacialis* Murdoch, *A. pusilla* Quatrefages, and *A. natalis* Girard, species concerning which comparatively little is known, have been found near Point Barrow (Alaska), Coquimbo (Chile), and Chelsea, Massachusetts, respectively. *A. natalis* is not a valid species; it is now merged with *A. marina* (see p. 6). I have recently shown that *A. pusilla* does not exhibit any characters which entitle it to retain individuality as a species and that it should be merged with *A. claparedii* (see p. 14). *A. glacialis* is shown in this memoir to be a distinct and valid species, although the characters given in the original diagnosis are insufficient to firmly establish it as such. I have investigated the original specimens on which Murdoch founded the species, and give below (see p. 24) a description of them in as much detail as is possible, having regard to their condition and their value as unique examples.

The external characters upon which reliance is placed in differentiating the caudate species of *Arenicola* are:

1. The number of chætigerous segments and the number of segments provided with gills.

2. The mode of branching of the gill axes. There are two principal modes of branching; in the first type, each of the axes of which the gill is composed bears lateral branches closely set or irregularly placed so that the gill has a bushy appearance: in the second type the lateral branches on each gill axis are more numerous and are placed at almost regular intervals, producing a pinnate appearance.

3. The relative size of the median and lateral lobes of the prostomium.<sup>a</sup>

4. The presence or absence of apertures of statocysts.<sup>a</sup>

5. The segments on which the apertures of the nephridia are situated.<sup>a</sup>

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<sup>a</sup> For the examination of the apertures of the statocysts and nephridia, the shape of the prostomial lobes and other minute features, a binocular dissecting microscope is almost indispensable.

6. The degree of development of the neuropodia, especially those of the first three or four, and of the last few chætigerous segments.

The setæ of several of the species of *Arenicola* present such close resemblance to each other that these structures are of comparatively little service in specific work and are not employed in diagnosis in the present paper; more reliable and more practicable characters are available.

It may be readily understood that in a considerable number of the specimens which have been collected and preserved some, at least, of the above-mentioned external characters are not available for reference. For instance, some features may have been damaged or destroyed at the time of capture or can no longer be seen, owing to the unsuitable mode of preservation adopted, or to the defective condition of the specimen brought about by its having been long kept in a medium which has partially lost its conserving powers. In specimens which have died contracted, owing to having been at once plunged into strong alcohol, the apertures of the nephridia and of the statocysts (if the latter pores are present) are invisible, the prostomium is so much withdrawn into the nuchal organ that the relative size of its lobes can not be ascertained, and the gills may be so fully contracted that the nature of the branching of their axes is indeterminable. In such cases the number of segments and the number of pairs of gills present are the only characters which can be seen, and they are insufficient to provide the basis for a reliable diagnosis. Even in some cases in which the external characters are moderately preserved the specific differences presented by these features are so small that great care is requisite if a safe diagnosis is to be reached. In all these cases it is necessary to have recourse to an examination of the internal organs before a definite determination of the species to which the specimen belongs can be made. If specimens from a new region are concerned it is particularly advisable not to depend upon the external characters alone, but to make an incision along the mid-dorsal line of the worm, extending from about the eleventh segment forward nearly to the prostomium, so as to permit an examination of all the important internal organs to be made. The making of such an incision and examination does not destroy any external feature or impair the value of the specimen for future study. The neglect of the examination of the internal organs has been responsible for many errors of diagnosis, some of which could scarcely have been made had these organs been even casually inspected.

The internal organs most useful in aiding specific determinations are:

1. The œsophageal glands or cœca, their number and comparative size.

2. The muscular pouches, a pair of which is present in several species, projecting backward from the ventral region of the first septum. The grade of development of these organs should be noted.

3. The nephridia, their number, the segments on which they open, and, in some cases, the character of the lips of the funnel.

4. The statocysts, when present, whether they are open or closed, and the number and nature of the statoliths which they contain.

ARENICOLA MARINA (Linnæus).

= *Arenicola piscatorum* LAMARCK.

Nineteen chætigerous segments; thirteen pairs of gills, the first, which is on the seventh segment<sup>a</sup>, may be small or absent; gills are usually bushy, but in some cases they approximate to the pinnate type; the three lobes of the prostomium are nearly equal in size; at any rate, the lateral lobes are seldom much larger than the median one; neuropodia are clearly visible in each segment, in the posterior branchial region they form long muscular ridges, and their grooves reach nearly to the mid-ventral line; six pairs of nephridia, which open on the fourth to the ninth segments;<sup>b</sup> one pair of œsophageal glands, conical or club-shaped; one pair of small globular, conical, or flask-shaped muscular pouches projecting backward from the ventral region of the first septum; a pair of statocysts in the peristomium, which open to the exterior (the apertures, which are often minute, are situated close to the points where each metastomial groove crosses the first interannular groove), the numerous statoliths are composed of sand grains, which may be enveloped to a greater or less extent with material secreted by the walls of the statocyst.

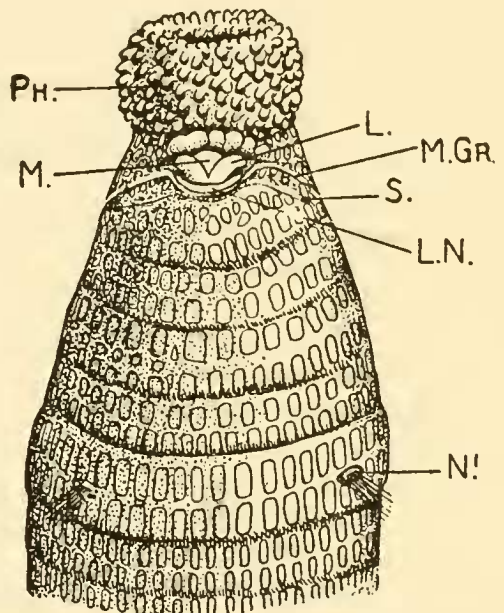


FIG. 1.—A. MARINA, ANTERIOR END, DORSAL ASPECT, TO SHOW THE PROSTOMIUM; L, LATERAL LOBE OF PROSTOMIUM; L. N., LIP OF NUCHAL ORGAN; M, MEDIAN LOBE OF PROSTOMIUM; M. GR., METASTOMIAL GROOVE; N<sup>1</sup>, FIRST NOTOPODIUM; PH, PHARYNX; S, APERTURE OF STATOCYST. X4.

<sup>a</sup> That is the seventh chætigerous segment. The word "segment" throughout the following pages means "chætigerous segment." The region anterior to the first chætigerous segment probably represents the peristomium and an achætous body segment, so that the first chætigerous is really the third true segment. See the author's memoir on *Arenicola*. Liverpool Marine Biology Committee, Memoirs, XI, 1904, p. 9.

<sup>b</sup> The first nephridium is not uncommonly reduced or even absent.

The previous records of this species from American stations are:

1. On the East coast—

- A. marina*, Labrador. J. H. ASHWORTH, Mitth. Kongl. Zool. Mus. Berlin, vol. 4, 1910, p. 349.
- A. piscatorum*, Belles Amours (Strait of Belle Isle). A. S. PACKARD, Mem. Boston Soc. Nat. Hist., vol. 1, 1867, p. 293.
- A. marina*, St. Lawrence. P. TAUBER, Annulata Danica, 1879, p. 110, Kjöbenhavn.
- A. piscatorum*, Grand Manan. W. STIMPSON, Smiths. Contr. Knowl., vol. 6, 1854, art. 5, p. 31.
- A. marina*, Grand Manan. F. W. GAMBLE and J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 422.
- A. marina*, New England. A. E. VERRILL, Trans. Conn. Acad. Arts and Sci., vol. 4. New Haven, 1881. (New England Annelida, annotated lists of species hitherto recorded.)
- A. marina*, Eastport, Maine. H. E. WEBSTER and J. E. BENEDICT, U. S. Fish Comm. Part 13, Rep. for 1885, p. 727. Washington, 1887.
- A. piscatorum*, Eastport, Maine. A. E. VERRILL, Bull. Essex Inst., vol. 3, 1872, p. 6, Salem, Massachusetts.
- A. marina*, Nahant, Massachusetts. F. W. GAMBLE and J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 423.
- A. natalis*, Chelsea, Massachusetts. C. GIRARD, Proc. Boston Soc. Nat. Hist., vol. 5, 1856, p. 88.
- A. piscatorum*, Massachusetts Bay. W. STIMPSON, Proc. Boston Soc. Nat. Hist., vol. 5, 1856, p. 114.
- A. marina*, Race Run, Massachusetts. H. E. WEBSTER and J. E. BENEDICT, U. S. Comm. Fish and Fisheries. Part 9, Rep. Commissioner for 1881, p. 725. Washington, 1884.
- A. marina*, Noank, Connecticut. A. E. VERRILL, Amer. Journ. Sci., ser. 3, vol. 10, 1875, p. 39.

2. On the West coast—

- A. marina*<sup>a</sup>, Vancouver Island. E. VON MARENZELLER, Zool. Jahrb. Abth. Syst., vol. 3, 1888, p. 12.
- A. marina*<sup>a</sup>, Puget Sound. C. M. CHILD, Trans. N. Y. Acad. Sci., vol. 16, 1898, p. 387.
- A. piscatorum*<sup>b</sup>, Bay of Paita. L. K. SCHMARDA, Neue wirbellose Thiere, vol. 1, pt. 2, p. 52, Leipzig, 1861.
- A. piscatorum*<sup>c</sup>, Callao. E. GRUBE, Vid. Medd. naturh. For. Kjöbenhavn for Aaret 1858, p. 120. Kjöbenhavn, 1859.
- A. marina*<sup>a</sup>, Puerto Montt, Chile. E. EHLERS, Festschr. K. Ges. Wiss. Göttingen, 1901, p. 176.

Rathbun<sup>d</sup> and Tauber<sup>e</sup> also mention the occurrence of this species on the shores of the United States.

*Remarks on the foregoing records.*—The specimens on which the species *A. natalis* Girard was founded are very shortly and insufficiently

<sup>a</sup> *A. claparedii*, see pp. 7, 8, 9.

<sup>b</sup> Probably *A. claparedii*, see p. 8.

<sup>c</sup> See p. 9.

<sup>d</sup> R. Rathbun. The Worms in: The Fisheries and Fishery Industries of the United States. Section 1. Washington, 1884, p. 833.

<sup>e</sup> Annulata Danica, p. 110.

described; no single character is mentioned by means of which the species with which Girard was dealing can be absolutely fixed. Nevertheless, it is, I consider, practically certain that the specimens in question were ordinary examples of *A. marina*. It is evident from the description that Girard mistook the ventral for the dorsal surface, for he speaks of the dorsal region as being marked by a conspicuous smooth line, which, upon the cephalic region, subdivides into right and left branches, which unite again anteriorly; this dorsal line is given as one of the principal specific features. This smooth band or line is, however, really ventral in position, and is seen in nearly all specimens of *A. marina* (and, indeed, in other caudate Arenicolidæ); it marks the position of the ventral nerve cord, and in front it is continuous with the metastomial grooves, which mark the course of the œsophageal connectives. I have endeavored to procure the type-specimen of this species, but without success; the curator of the museum of the Boston Society of Natural History informs me (letter dated, November 4, 1908) that he has not been able to locate the type and that there is no record of its having been given to the Society. There can be little doubt that the specimens were examples of *A. marina*, which species, as may be seen from the list of records given above, has been found at other stations in the immediate neighborhood of Chelsea.

There are two specimens in the Museum of Comparative Zoology, Cambridge, Massachusetts, which were collected at Grand Manan and bear the label "*Arenicola natalis* Girard." (Mus. No. 87.) I have re-examined these and have no hesitation in referring them to the species *A. marina*, with which they agree in every respect, both in regard to external characters and internal organs.

The records from Vancouver Island, Puget Sound, the Bay of Paita, Callao, and Puerto Montt can not be passed without emendation.

Von Marenzeller<sup>a</sup> states that he examined examples of *A. marina* from Vancouver Island. As his diagnosis was reached from a consideration of the external characters only it seemed to me that a re-examination, which should include the internal organs, was desirable. Professor von Marenzeller kindly lent me a specimen for this purpose. The specimen is about 70 mm. long and looks at first sight like a small example of *A. marina*, except that the lateral lobes of its prostomium are proportionately larger than those of *A. marina*. Although I had a suspicion that it should not be referred to this species, it was impossible to finally determine this point by an examination of the external features only. Accordingly, an incision was made along the greater part of the worm and the flaps of the body wall turned aside. It was then seen that instead of a single pair of

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<sup>a</sup> Zool. Jahrb. Abth. Syst., vol. 3, 1888, p. 12.

œsophageal glands, as in *A. marina*, this specimen has five pairs, the first being 9 to 10 mm. long and the others 1.5 to 3.5 mm. long. There are no muscular pouches on the first diaphragm (these structures are present in *A. marina*), and statocysts could not be found after careful search.<sup>a</sup> Five pairs of nephridia are present, opening on the fifth to the ninth segments. These internal characters and the nature of the prostomium indicate that the worm is to be referred to the species *A. claparedii* Levinsen. Child's record of *A. marina* from Puget Sound is founded on a misapprehension. He was concerned with the cytology of the ova and probably did not make any examination of the systematic characters of the worms. Johnson<sup>b</sup> states that the specimens examined and recorded by him as *A. claparedii* were given to him by Child; moreover, subsequent records of specimens from Puget Sound and all the specimens from that area which I have myself examined belong to the species *A. claparedii*. We need therefore have no hesitation in transferring Child's record from *A. marina* to *A. claparedii*.

Schmarda records *A. piscatorum* from the Bay of Paita, but a statement in his description shows that he was not dealing with this species, for he mentions the presence of twenty glandular sacs just anterior to the stomach, that is, the specimen had twenty œsophageal glands, whereas *A. marina* has only two. I have tried to find Schmarda's specimens, but have failed to do so. Prof. Dr. K. Grobben has been good enough to look through the catalogue of the collection in the Zoological Institute of Vienna, where I thought the specimens might possibly be, but there is no example of *Arenicola* in that collection from the Bay of Paita and no specimen of this genus collected by Schmarda. His specimens from Paita were examples either of *A. claparedii* or *A. assimilis*, probably the former, judging from the distribution of these species (see p. 17 and p. 20). At any rate they can not be examples of *A. marina*, as is definitely shown by the number of their œsophageal glands, and we may provisionally regard them as belonging to the species *A. claparedii*.<sup>c</sup>

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<sup>a</sup>In order to definitely establish the absence of statocysts, it would be necessary to cut serial sections of the anterior end of the worm, but this was impossible in the present instance.

<sup>b</sup>H. P. Johnson, Proc. Boston Soc. Nat. Hist., vol. 29, 1901, p. 422.

<sup>c</sup>It should be borne in mind that, at the period when the records by Schmarda (1861) and Grube (1859) were published, *A. marina*, or, as it was then almost universally called, *A. piscatorum*, was the only known caudate species of *Arenicola* with nineteen segments and thirteen pairs of gills. It was not until 1883 that Levinsen pointed out the characters which distinguish *A. claparedii* from *A. marina*. It is easy to understand that up to that time all specimens of *Arenicola* with nineteen segments and thirteen pairs of gills would be at once referred to the species *A. marina*, a practice which prevailed, with one or two exceptions, until little over ten years ago.



Grube's record of "*Arenicola piscatorum* Cuv." from Callao is a mere mention of the name without any comment whatever. In the hope of finding this specimen I wrote to Professor Levinsen, of the Museum of Copenhagen (in the publications of which museum the record was published), but he informs me that he can not find any corresponding specimen in the museum collection. I have therefore no means of verifying or amending this record by reference to the actual specimen, but I consider that, as a record of *A. marina*, it should be only provisionally given. It is equally, if not more, probable that Grube was dealing with one of the species externally closely similar to *A. marina*, for instance, *A. claparedii*.<sup>a</sup>

Ehlers records *A. marina* from Puerto Montt, Chile. Fortunately, the two specimens on which the record is based have been kept. I am indebted to Professor Ehlers and to Doctor Michaelsen of the Naturhistorisches Museum, Hamburg, to which institution the specimens belong, for the opportunity and permission to examine them. The worms are both dark colored, nearly black and badly preserved, 123 and 110 mm. long, respectively; the longer one is apparently incomplete, the posterior end of the tail being absent. In the number of their segments and the number and position of their gills, almost the only external characters available for reference, these specimens agree with *A. marina*, but on examining the internal organs of one of them which had already been partially dissected, it was evident that the specimen could no longer be referred to this species. Ten œsophageal glands are present on each side; there are no pouches on the first septum, and statocysts could not be found in spite of most careful search. The internal organs of the other specimen were also examined; seventeen œsophageal glands are present, but no septal pouches and no statocysts. The anterior region of one of the specimens was cut into serial sections, but statocysts could not be found. Had these vesicles been present in the living animal they would have been recognizable even though the tissue was so badly preserved. We may conclude that these specimens do not possess statocysts and that they belong to the species *A. claparedii*, the only species in which statocysts are absent. The gills, though not in a good state of preservation, are of the pinnate type and the neuropodia of the posterior branchial region are broad cushions not nearly reaching the mid-ventral line; both these characters confirm the diagnosis previously reached. The lobes of the prostomium are not sufficiently well preserved to be of service in diagnosis. Both these specimens are remarkable in that they possess six pairs of nephridia, while typical specimens of *A. claparedii* have only five pairs. Each of the first

<sup>a</sup> See footnote c on page 8.

nephridia, in both specimens, is in contact at its anterior end with the third septum, but in none of them could a nephridial funnel be seen on the anterior face of this septum. Possibly these nephridia were, in life, not provided with funnels, i. e., they were incomplete or reduced, as not uncommonly happens in the case of the corresponding first nephridium in *A. marina*, but the very defective preservation of the specimens does not permit me to determine this point decisively. The vesicles of some of the other nephridia are strongly dilated; a similar condition has been observed in the nephridial vesicles of other species of *Arenicola* in the breeding season. The condition of the nephridial vesicles suggests that the specimens were sexually mature. They were collected on June 17, 1900.

The records of *A. marina* from Vancouver Island, Puget Sound, and Puerto Montt are shown above to be invalid; the specimens on which the records were founded have been re-examined and shown to belong to the species *A. claparedii*, under which they are now to be recorded. (See p. 12, footnote *b*, and p. 14.) Schmarda's record of *A. piscatorum* from the Bay of Paita should also no longer be credited to this species, but probably to *A. claparedii*, and Grube's record of *A. piscatorum* from Callao should be accepted with reserve. There is therefore no certain record of the occurrence of *A. marina* on the west coast of North or South America.

I have examined specimens of *A. marina* from the following stations on the eastern coast of North America:

- Rigolet, Labrador. [83.]
- Cape Breton, Nova Scotia. [23662.]
- Halifax, Nova Scotia. [8931.]
- Eastport, Maine. [546, 587.]
- Gloucester, Massachusetts. [9365, 9368.]
- Provincetown, Massachusetts. [219.]<sup>a</sup>
- Barnstable, Massachusetts. [No number.]
- Woods Hole, Massachusetts.
- Buzzard's Bay, Massachusetts. [9367.]

All the specimens, except those from Woods Hole, are in the collection of the U. S. National Museum. The numbers in brackets are the registration numbers.

Before leaving the consideration of this species of *Arenicola*, I wish to refer briefly to a specimen in the collection of the Zoological Insti-

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<sup>a</sup> Webster and Benedict (U. S. Comm. Fish and Fisheries, part 9, Rept. Commissioner for 1881, p. 725, Washington, 1884) state that *A. marina* was not found at Provincetown or at Wellfleet although it was carefully looked for, but the former author evidently made a further and successful search, for the bottle No. 219, which contains nineteen specimens, bears the note "From H. E. Webster."

tute of the University of Vienna, for the opportunity of examining which I am indebted to the kindness of Prof. Dr. K. Grobben. This is a single specimen labeled, "*A. piscatorum*, Chile, No. 253," and added in pencil are the words "var. *carbonaria*." The specimen is not in a good state of preservation, its muscles are very relaxed, and the tail region is broken into two pieces. Its total length is 300 mm., of which the tail, only a portion of which is present, represents 50 mm. The external characters and internal organs of this specimen agree absolutely with those of *A. marina*; it certainly belongs to this species. There is unfortunately no information available either as to the history or the exact place of capture of this worm. If it be really from Chile, it is, so far as I am aware, the only known specimen of *Arenicola marina* from the west coast of America.

*Summary of the distribution of Arenicola marina on American shores.*—*Arenicola marina* has been recorded from a considerable number of stations on the eastern coast of North America, from Rigolet, Labrador, in the north to Noank, Connecticut, in the south. Although there have been a few records of *A. marina* from the west coast of North and South America, a re-examination of all the recorded specimens still in existence has shown that they are examples of *A. claparedii*. The only specimen of *A. marina* which I have seen from the west coast of America is one in the Museum of the Zoological Institute of Vienna, said to be from Chile, but no information regarding the history of the specimen or the exact station where it was captured is available.

*Further distribution of A. marina.*—The shores of the White Sea, Siberia, Norway, Sweden, Denmark, Germany, Holland, Belgium, the British Isles, France, Portugal, the Mediterranean (a few stations only, for instance, Trieste), the Faroe Islands, Iceland, Greenland, the Marquesas and Kingsmill (Gilbert) Islands.

#### ARENICOLA CLAPAREDII Levinsen.

Nineteen chætigerous segments; thirteen pairs of gills, the first, which is on the seventh segment, may be small or absent; gills usually of the pinnate type but may be bushy; lateral lobes of the prostomium very large, much larger than the median lobe, and often folded in their anterior portion (fig. 2); neuropodia clearly visible in each segment, those of the posterior branchial region are wide antero-posteriorly, forming cushion-like pads, but are not so long as those of *A. marina*, so that neither the muscular ridge nor the groove which contains the crotchets, approaches the mid-ventral line; five

pairs of nephridia which open on the fifth to the ninth segments<sup>a</sup>; several (four to sixteen) pairs of œsophageal glands, the anterior pair long and slender, the others shorter and more or less pear-shaped; no pouches on the first septum; statocysts absent. This last is a most noteworthy feature, and is diagnostic of the species, for all other known species of *Arenicola* possess statocysts.

This species has been hitherto recorded from only three stations on the American coast, namely:

*A. claparedii*, Crescent City, California. F. W. GAMBLE, and J. H. ASHWORTH. Quart. Journ. Micr. Sci., vol. 43, 1900, p. 423.

*A. claparedii*, Crescent City, California. J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 46, 1903, pp. 773-774.

*A. claparedii*, Puget Sound,<sup>b</sup> Washington. H. P. JOHNSON, Proc. Boston. Soc. Nat. Hist., vol. 29, p. 421, 1901.

*A. claparedii*, Puget Sound, Washington. J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 46, 1903, p. 774.

*A. claparedii*,<sup>c</sup> Falkland Islands. E. M. PRATT, Mem. Proc. Manchester Lit. Philos. Soc., vol. 45, no. 13, p. 12; no. 14, p. 15, 1901.

*A. claparedii*,<sup>c</sup> Falkland Islands. R. VALLENTIN, Mem. Proc. Manchester Lit. Philos. Soc., vol. 48, no. 23, p. 9, 1904.

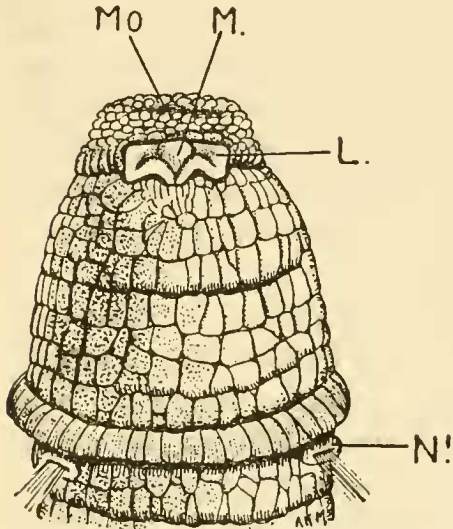


FIG. 2.—*A. CLAPAREDII*, ANTERIOR END, DORSAL ASPECT OF SPECIMEN FROM CRESCENT CITY, CALIFORNIA, TO SHOW THE PROSTOMIUM. *L*, LATERAL LOBE OF PROSTOMIUM; *M*, MEDIAN LOBE; *Mo*, MOUTH; *N*<sup>1</sup>, FIRST NOTOPODIUM.  $\times 6$ .

The records from Crescent City and Puget Sound hold good, but those from the Falkland Islands must be transferred to the species *A. assimilis*. Miss Pratt's record is founded on certain post-larval specimens of *Arenicola* taken by Mr. Vallentin in Stanley Harbor. These post-larval specimens were subsequently re-examined, two of them were sectioned, with the result that they were conclusively shown to be young stages of *A. assimilis*, var. *affinis*.<sup>d</sup> Mr. Vallentin's record is undoubtedly based on Miss Pratt's. All the specimens of *Arenicola* which he collected in the Falkland Islands were examined by me and it was from them that I described the new variety *affinis* of *A. assimilis* in the paper cited<sup>d</sup> (pp. 768-772). All the specimens belong to this variety; there is no example of *A. claparedii* among them.

The specimens, five in number, from Crescent City, are in the Museum of Comparative Zoology, Cambridge, Massachusetts (register

<sup>a</sup> Out of 100 specimens examined I have seen only three which depart from this condition; in each of these there was also a nephridium opening on the fourth segment. These three specimens were from the west coast of South America, namely, from Coquimbo ("*A. pusilla*" Quatrefages) and from Puerto Montt, Chile. See also p. 16.

<sup>b</sup> This species was also obtained in Puget Sound by C. M. Child, but was erroneously stated to be *A. marina*. (Trans. N. Y. Acad. Sci., vol. 16, 1898, p. 387.) See p. 8.

<sup>c</sup> *A. assimilis*, var. *affinis*. See the lower part of this page.

<sup>d</sup> J. H. Ashworth, Quart. Journ. Micr. Sci., vol. 46, 1903, pp. 764-768.

number 91); there is another, doubtless from the same batch, in the Museum of the Zoological Institute, Göttingen (no. 27a). In four of those in the Harvard collection and in the Göttingen example the seventh segment is abbranchiate, the first gill being borne on the eighth segment; the fifth Harvard specimen has a pair of very small gills on the seventh segment. These specimens vary in length from 105 mm. (of which the tail forms 13 mm.) to 207 mm. The tail of the latter specimen reaches the extraordinary proportion of 117 mm.

A specimen from Puget Sound, from the collection of H. P. Johnson, is preserved in the Harvard Museum (no. 956) and another is in the Department of Biology, University of California (no. 1066). The former is 94 mm. and the latter 60 mm. long, of which in each case the tail forms 13 to 14 mm., but the posterior end is apparently incomplete in both cases. In both these and in two other specimens from the same collection, given to me by Doctor Johnson, the first gill is borne by the seventh segment, but in one specimen there is a gill only on the right side of that segment, the corresponding gill of the left side being absent.

There are examples of this species in the Smithsonian Collection from Constantine Harbor, Amchitka Island, Aleutian Islands (1047); Atka Island, Aleutian Islands (no number); Sand Point, Humboldt Bay, California (no number).

The single specimen from Humboldt Bay, the one from Amchitka Island, and one of the four from Atka Island were opened in order to see the internal organs. All are typical examples of the species in regard to both their external and internal features, prostomium, neuropodia, nephridia, œsophageal glands, absence of septal pouches; statocysts could not be found on dissection of the anterior region of these specimens. In the case of the dissected specimen from Atka Island, the region in which the right statocyst is situated in those species which possess these organs, was excised and cut into serial sections, an examination of which proves that a statocyst is not present in this worm.

I have recently examined seven specimens from Dutch Harbor, Unalaska (Harriman Expedition), and a dozen specimens collected at San Juan Island, in the Strait of Juan de Fuca. All are typical examples of *A. claparedii*, and in all the first true gill is present. The absence of statocysts was determined in a large specimen from Unalaska by dissection, and in the case of those from San Juan by examination of serial sections of the anterior end of one of the worms.

The specimens from Unalaska are the largest examples of this species I have seen. Their length, 132 to 160 mm., is not specially remarkable, but they are of massive build, the four largest specimens have a girth (measured at the fifth segment) of 50 to 60 mm.

*Arenicola claparedii* has been taken at three other points on the western seaboard of America, but was recorded under other names. To the records given above the following should therefore be added:

*A. marina*, Vancouver Island. E. VON MARENZELLER, Zool. Jahrb. Abth. Syst., vol. 3, 1888, p. 12.

*A. pusilla*, Coquimbo, Chile. A. DE QUATREFAGES, Histoire naturelle des Annelés, p. 266, Paris, 1865.

*A. marina*, Puerto Montt, Chile. E. EHLERS, Festschr K. Ges. Wiss. Göttingen, 1901, p. 176.

I have shown above that a re-examination of one of von Marenzeller's specimens from Vancouver Island (see p. 7) and of the two

specimens recorded by Ehlers from Puerto Montt (see p. 9) clearly proves that they do not belong to the species *A. marina*, but to *A. claparedii*.

The specimen from Coquimbo is the type-specimen of *A. pusilla*, de Quatrefages, the characters of which were thus defined: "Annuli ebranchiati 9. Branchiæ magnæ ramosissimæ." These diagnostic features are so inadequate that the position of this species with regard to other species of *Arenicola* has been quite indeterminable, and indeed it has been impossible to decide whether or not this species is a valid one. I have recently made an exhaustive examination of this

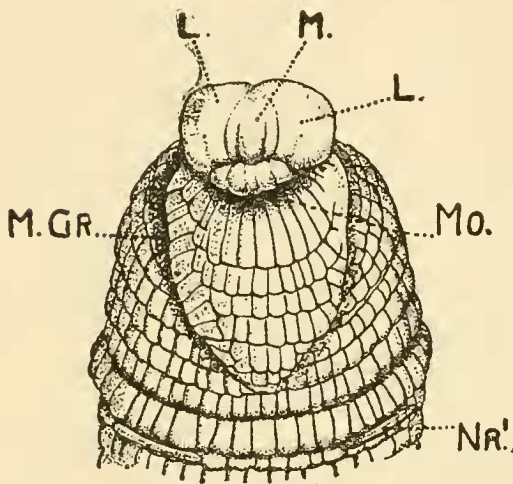


FIG. 3.—ANTERO-VENTRAL VIEW OF THE ANTERIOR PORTION OF "A. PUSILLA" QUATREFAGES. IN THIS VIEW ALL THE PARTS, EXCEPT THE PROSTOMIUM, ARE SEEN SOMEWHAT FORESHORTENED.  $\times 8$ . L, LATERAL LOBES OF PROSTOMIUM; M, MEDIAN LOBE; M. GR, METASTOMIAL GROOVE; Mo, MOUTH; Nr<sup>1</sup>, FIRST NEUROPODIUM.

specimen as far as is possible without damaging its diagnostic features. It is small, slender, and incomplete, only the anterior region, as far back as the eleventh chætigerous annulus, being preserved. It is about 35 mm. long and 3 to 3.5 mm. in diameter. The first gill is borne on the eighth segment (not the tenth, as stated by de Quatrefages), but is small. The other gills are larger and tend toward the pinnate type. The first seven neuropodia are feebly developed, those of the succeeding segments are larger, and those of the tenth and eleventh segments form well-developed cushion-like ridges. The setæ are very similar to those of Californian examples of *A. claparedii*. The prostomium is very fully everted, carried forward, and, as it were, displayed over the anterior end of the worm so that, in order to obtain a view of its lobes, an antero-ventral view is necessary (fig. 3). The lateral lobes of the prostomium are in the form of two flattened disks, the edges only of which are visible in a

dorsal view of the worm; their flat faces are well seen on looking at the worm from the anterior aspect. The lateral lobes envelop the smaller median lobe posteriorly and laterally. As seen from the dorsal aspect (fig. 4) the lateral lobes of the prostomium are widely divaricated, and immediately behind their point of union there is a small median structure (P) which lies in the nuchal groove, its posterior and slightly narrower end being hidden in the median portion of the nuchal organ. This little structure seems to have been regarded by Fauvel, who examined the external characters of the specimen about eleven years ago, as the median lobe of the prostomium,<sup>a</sup> but, as we have already seen, the true median lobe is anterior to the point of union of the lateral lobes (as it is in other species of *Arenicola*) while the lobe under discussion is posterior to this junction. This structure is the most posterior portion of the prostomium, only a very small portion, or none, of which is usually visible, because it is generally almost or entirely hidden in the nuchal organ; the extreme protrusion of the prostomium in this specimen has brought this posterior median portion into view. The examination of the internal organs of this worm showed that there are six pairs of nephridia opening on the fourth to the ninth segments, twelve œsophageal glands (six on each side), and that septal pouches are not present. Most careful examination of the region in which statocysts should be looked for failed to reveal their presence; to definitely establish their absence it would be necessary to make serial sections of a portion of the anterior end of the worm, but that is, of course, precluded in this case. I can only say, therefore, that, having very carefully searched for the statocysts, as far as was possible in such a valuable specimen, I believe them to be absent.

We have now the information at our disposal to enable us to determine whether *A. pusilla* de Quatrefages is henceforward to be regarded as a valid species or whether it should be merged with one of the better-known species. It is clear that the diagnosis given by de Quatrefages is erroneous, for gills are borne on the eighth and ninth segments. The comparatively high grade of development of the gills mentioned by de Quatrefages is not a definite character on which to found a

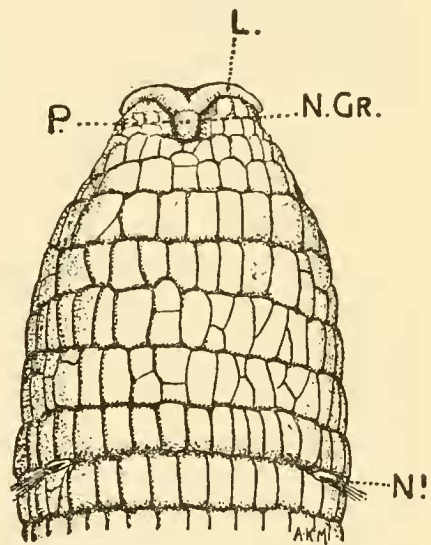


FIG. 4.—DORSAL VIEW OF THE ANTERIOR END OF "*A. PUSILLA*" QUATREFAGES SHOWING THE WIDELY DIVARICATED LATERAL LOBES (L) AND THE MEDIAN POSTERIOR PORTION (P) OF THE PROSTOMIUM (N!) FIRST NOTOPODIUM; (N.G.R) NUCHAL GROOVE.  $\times 8$ .

<sup>a</sup> "Petit lobe médian triangulaire." Mem. Soc. Nation. Sci. Nat. Math. Cherbourg, vol. 31, 1899, p. 177.

species; at least two other externally similar species of *Arenicola* have gills as highly developed as those of *A. pusilla*. The characters given in the original diagnosis of the species *A. pusilla*, one of them erroneous, the other insufficient, can not be held to establish it as a valid species, nor is there any feature of the internal anatomy which marks this specimen as unique.

The most striking of the external features of *A. pusilla* is undoubtedly its prostomium, the high grade of development of the lateral

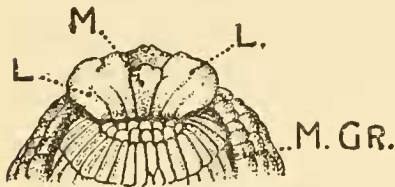


FIG. 5.—ANTERO-VENTRAL VIEW OF THE ANTERIOR END OF A SPECIMEN OF *A. CLAPAREDII* FROM CRESCENT CITY, CALIFORNIA.  $\times 6$ . FOR LETTERING SEE FIG. 3.

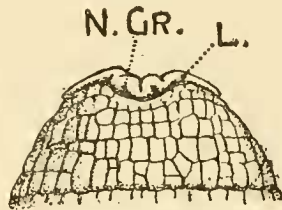


FIG. 6.—DORSAL VIEW OF THE ANTERIOR END OF THE SAME SPECIMEN.  $\times 6$ . FOR LETTERING SEE FIG. 4.

lobes of which is paralleled, among known species, only in *A. claparedii*. Figs. 5 and 6 represent the anterior end of a specimen of *A. claparedii* from Crescent City, California (Harvard Collection), which has a

prostomium of the same type as that of *A. pusilla*, although owing to contraction in the oral region at the time of preservation the ventral portions of the lateral lobes of the Californian specimen have been brought nearer together and have unduly compressed the median lobe. Nevertheless it is obvious that the Californian specimen and *A. pusilla* have prostomia of an identical type, and that the latter specimen, judged by its prostomium, is to be referred to the species *A. claparedii*. This diagnosis is confirmed by the examination of the internal organs, the results of which are given above (p. 15), particularly by the absence of statocysts, which is a feature of special significance. The only point of difference in regard to the internal organs between *A. pusilla* and *A. claparedii* is that in the former there are six pairs of nephridia and in the latter typically only five pairs, there being usually no nephridium opening on the fourth segment. But this sole difference is not important; certainly it is not one which would justify the separation of two otherwise identical forms. The two examples of *A. claparedii* from Puerto Montt (see p. 10) have also six pairs of nephridia; this may be a character of the Chilean race of the species. We may conclude that the specimen of *A. pusilla* de Quatrefages is a fragment of a small example of *A. claparedii* Levinsen; had it been complete it would probably have been about 80 to 90 mm. in length. A more detailed account of "*A. pusilla*" and discussion of its affinities will be found in a forthcoming paper, by the present writer, in *Annales des Sciences Naturelles, Zoologie*, ser. 9, vol. 10, Paris, 1910.

In his account of the specimens of *A. claparedii* from Puget Sound Johnson<sup>a</sup> states that "the only notable points of difference between

<sup>a</sup> Proc. Boston Soc. Nat. Hist., vol. 29, p. 1901, p. 421.



the Puget Sound specimens and those from Naples are the vastly greater size—at least eight times as great—of the former and the smaller number of œsophageal cœca or pouches in the latter.” The difference in regard to the number of œsophageal cœca in specimens from Naples and the western seaboard of America seems to be a clear one, and is sometimes even striking. Neapolitan specimens seldom have more than four pairs of cœca, but I have seen only one American example with as few as five pairs; the others had six, eight, nine, and ten pairs, and Johnson records specimens with fifteen and sixteen pairs, and one with sixteen cœca on the right and eighteen on the left side. Johnson’s remark regarding the comparative size of Neapolitan and American specimens is not in agreement with my experience; possibly he had been supplied with very small Neapolitan examples. There is not so great a difference in the length of specimens from the two regions. I have seen sixteen specimens from Puget Sound, including four from Johnson’s collection, the largest of which is 103 mm. long (of which the tail forms 28 mm.), and 11 of them are less than 50 mm. long. I have recently had a Neapolitan example 97 mm. long (of which the tail forms 20 mm.), and the average length of nine specimens which have just passed through my hands is 80 mm. (of which the tail forms 17 mm.). Lo Bianco states that examples of this species from the Bay of Naples attain a length of 150 mm.<sup>a</sup> The longest American specimen of *A. claparedii* I have seen is one from Crescent City, California, in the Harvard collection, which is 207 mm. long, but this great length is largely accounted for by the unusual extent of the tail, which measures no less than 117 mm. American specimens have generally a thicker body wall than Neapolitan ones, and are stouter; among the scores of living and preserved Neapolitan examples of this species which I have examined I never saw any whose girth approached that of the massive specimens from Unalaska. (See p. 13.)

*Summary of the distribution of Arenicola claparedii on American shores.*—*Arenicola claparedii* is now known from several stations on the western seaboard of America, namely, the Aleutian Islands (Amchitka, Atka, Unalaska), Vancouver Island, San Juan Island, Puget Sound, Crescent City and Humboldt Bay, California; Coquimbo and Puerto Montt (Chile).

*Further distribution.*—Naples, Ossero (Adriatic), Angra Pequena (southwest Africa), and North Japan.

#### ARENICOLA ASSIMILIS Ehlers.

Twenty chætigerous segments; thirteen pairs of gills, the first, which is on the eighth segment, may be small or absent; the gills may be bushy or may tend toward the pinnate type, but are seldom clearly and typically pinnate; median lobe of the prostomium

<sup>a</sup> Atti R. Accad. Sc. fis. mat., Napoli, vol. 5, ser. 2, 1893, no. 11, p. 9.

large or moderately large, lateral lobes in the form of a V, the limbs of uniform width, not dilated anteriorly, though they may be bent (figs. 7, 8); neuropodia similar to those of *A. claparedii*; six pairs of nephridia, which open on the fourth to the ninth segments; several (6 to 15) pairs of œsophageal glands, the anterior pair long and slender, the others smaller and more or less pear-shaped; no pouches on the first septum; a pair of large statocysts in the peristomium, which open to the exterior; statoliths numerous, spherical or rounded secreted chitinoid bodies.

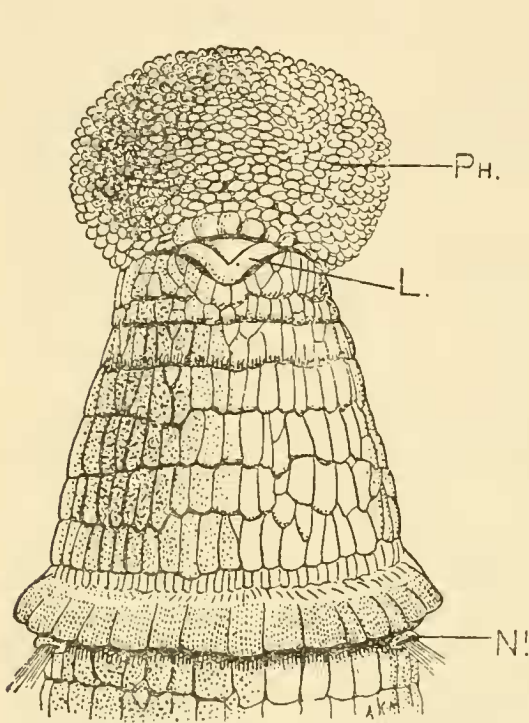


FIG. 7.—*A. ASSIMILIS*, ANTERIOR END, DORSAL ASPECT, OF SPECIMEN FROM USCHUAIA. THE PROSTOMIUM IS IN A STATE OF NORMAL EXTENSION. FOR LETTERING SEE FIG. 8.  $\times 6$ .

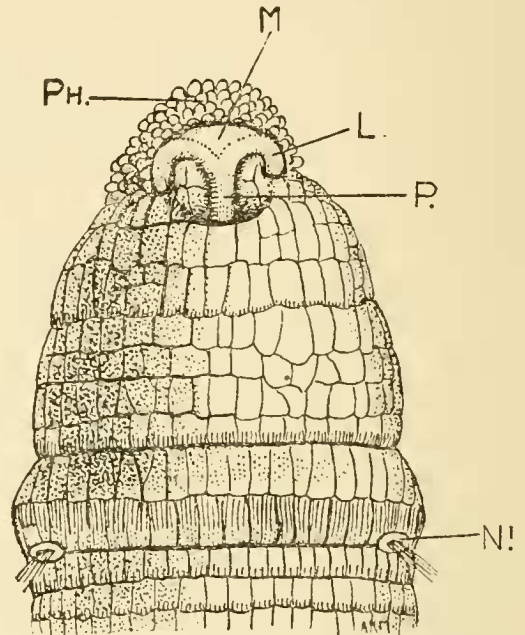


FIG. 8.—*A. ASSIMILIS*, VAR. *AFFINIS*, ANTERIOR END, DORSAL ASPECT, OF SPECIMEN FROM THE FALKLAND ISLANDS. THE PROSTOMIUM IS PROTRUDED TO ITS FULLEST EXTENT.  $\times 6$ . *L*, LATERAL LOBE OF PROSTOMIUM; *M*, MEDIAN LOBE; *N!*, FIRST NOTOPODIUM; *P*, MEDIAN POSTERIOR PORTION OF PROSTOMIUM; *PH*, PHARYNX.

*ARENICOLA ASSIMILIS*, var. *AFFINIS* Ashworth.

Nineteen chætigerous segments; thirteen pairs of gills, the first, which is liable to reduction, on the seventh segment. Statoliths numerous, consisting of either foreign bodies, such as quartz grains, or of rounded secreted chitinoid bodies. Other characters as given above for *A. assimilis* Ehlers.

*A. assimilis* has been recorded from—

California.<sup>a</sup> E. EHLERS, Polychaeten, p. 104, in Hamburger Magalhaensische Sammelreise, Hamburg, 1897.

Punta Arenas (Strait of Magellan), Lapataia Nueva (Beagle Channel) and Uschuaia (Tierra del Fuego). E. EHLERS, Polychaeten, p. 104, in Hamburger Magalhaensische Sammelreise, Hamburg, 1897; also Festschr. K. Ges. Wiss. Göttingen, 1901, p. 178.

Susanna Cove (Strait of Magellan).<sup>b</sup> E. EHLERS, Polychaeten, p. 104, in Hamburger Magalhaensische Sammelreise, Hamburg, 1901; also Zool. Jahrb., Suppl. 5, Fauna Chilensis, vol. 2, pp. 265, 269, 1901.

South Georgia. E. EHLERS, Polychaeten, p. 104, in Hamburger Magalhaensische Sammelreise, Hamburg, 1897; also Festschr. K. Ges. Wiss. Göttingen, 1901, p. 178.

<sup>a</sup> Transfer to *A. claparedii*, see p. 19.

<sup>b</sup> Transfer to var. *affinis*, see p. 19.

Schmarda's record of *A. piscatorum* from the Bay of Paita (see p. 8) is included by Ehlers under the species *A. assimilis* (Festschr. Göttingen, p. 178).

The variety *affinis* of *A. assimilis* is recorded from the following stations on or near the American coast:

Falkland Islands. J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 46, 1903, pp. 764-772.

Susanna Cove (Strait of Magellan). J. H. ASHWORTH, Mitth. Kongl. Zool. Mus. Berlin, vol. 4, 1910, p. 352.

The specimen on which the record of *A. assimilis* from California is based is in the Göttingen Museum and, by the courtesy of Professor Ehlers, I have been permitted to examine it. Professor Ehlers informed me that this is a duplicate from Professor Agassiz's collection, which was sent to Göttingen to be examined. The remaining specimens were returned to Professor Agassiz and are doubtless those which I have at present in my hands from the Harvard collection (bottle No. 91). I have compared the Göttingen specimen with the Harvard examples and find that they agree in every respect. In the former there are nineteen chætigerous segments, the first of the twelve pairs of gills is on the eighth segment; there are five pairs of nephridia which open on the fifth to the ninth segments; there is no nephridiopore on the fourth segment; the lateral lobes of the prostomium are well developed, and in pigmentation and general appearance this specimen agrees absolutely with the Harvard specimens of *A. claparedii* from California (see p. 12). I have no hesitation, after making this direct comparison, in confirming the opinion which I expressed in 1903<sup>a</sup> that Ehlers is in error in recording *A. assimilis* from California; the record should be transferred to *A. claparedii*.

It is very probable that Schmarda's specimen, regarded by Ehlers as *A. assimilis*, was really *A. claparedii*; the point at which the specimen was obtained (the Bay of Paita) is within the known range of *A. claparedii*, but is over 3,000 miles north of the nearest station from which *A. assimilis* has been recorded.

Through the kindness of Doctor Michaelsen, of the Hamburg Museum, I have been enabled to examine specimens of *A. assimilis* from Punta Arenas, Lapataia Nueva, Uschuaia, and South Georgia, and the specimens from Susanna Cove, now in the Königliche Zoologisches Museum, Berlin, were recently entrusted to me for examination by Director Brauer. The examples from Punta Arenas, Uschuaia, and South Georgia have twenty chætigerous segments and are typical specimens of *A. assimilis*, but those from Lapataia Nueva and Susanna Cove—the original examples determined by Ehlers, as the accompanying labels testify—have only nineteen segments and are referable to the variety *affinis*.

<sup>a</sup> Quart. Journ. Micr. Sci. vol. 46, 1903, p. 774.

A post-larval specimen with nineteen segments and therefore referable to the variety *affinis*, was recorded by Ehlers from Uschuaia among the "roots" of *Fucus*.

*Summary of the distribution of Arenicola assimilis on American shores.*—Typical examples of *A. assimilis* have been found at Punta Arenas (Strait of Magellan), Uschuaia (Beagle Channel), and South Georgia.

Examples referable to the variety *affinis* are known from Uschuaia (a gill-less post-larval specimen), Lapataia Nueva (Beagle Channel), Susanna Cove (Strait of Magellan), and the Falkland Islands.

*Further distribution.*—Typical examples of *A. assimilis* have not yet been recorded from any other stations than those mentioned above. The variety *affinis* is, however, found also at Otago Harbor, New Zealand, and Stewart Island,<sup>a</sup> and at Kerguelen.<sup>b</sup>

*Remarks on Arenicola assimilis.*—The three caudate species of *Arenicola*—*marina*, *claparedii*, and *cristata*, present a remarkable constancy in the number of their chætigerous segments and in the segments on which gills are borne. Only in rare cases is an additional chætigerous segment found at the posterior end of the branchial region, and very rarely does this segment bear gills. Among the thousands of specimens of *A. marina* which have passed through my hands during the last few years I have seen only three with a complete chætigerous and branchiate twentieth segment.

Ehlers separated *A. assimilis* from *A. marina* because in the former the first gill was not on the seventh but on the eighth or ninth segment. But the number of chætigerous segments is a still more striking character, and, in view of the constancy in the number of these segments in the other caudate species, it seemed to me that the occurrence of examples of *A. assimilis* with twenty and others with nineteen chætigerous segments called for recognition. It was on these grounds that, in 1903, I established the variety *affinis* for those examples of *A. assimilis* with only nineteen chætigerous segments. The varietal and typical specimens are, however, very closely related; the only differences between them are in regard to the number of segments and the position of the first gill.

*A. assimilis* (in the wider sense, that is, including the variety) is clearly the characteristic species of the southern regions. It extends from Tierra del Fuego, by way of the Falkland Islands, South Georgia, and Kerguelen, to New Zealand. The most northerly station from which it has been recorded is Otago Harbor, about 46 degrees south.

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<sup>a</sup> Unpublished record, from the manuscript of the present writer.

<sup>b</sup> This specimen from Kerguelen, recorded by Grube (Monatsb. K. Preuss. Akad. Wiss. Berlin, aus dem Jahre 1877, 1878, p. 511) as *A. piscatorum* Cuvier var., is now in the Königlische Zoologisches Museum, Berlin. I have recently examined it, and conclude that it is to be referred to the species *A. assimilis* var. *affinis*.

The distribution of this species presents a remarkable parallel to that of certain Oligochætes. Beddard<sup>a</sup> has pointed out that the characteristic earthworms of New Zealand are Acanthodrilidæ, and that the same family is equally characteristic of Patagonia. This close resemblance, in regard to their earthworms, between Patagonia and New Zealand is accentuated by the fact that the only earthworms known from the intervening localities, the Falklands, South Georgia, Marion, and Kerguelen islands, belong to the genus *Acanthodrilus*. Beddard regards these facts as evidence in favor of a former greater extension northward of the circumpolar antarctic continent, and he is inclined to believe that this region did not include the Cape of Good Hope. The evidence afforded by the distribution of the earthworms points to a more recent communication between Patagonia and New Zealand than between either of these countries and the Cape of Good Hope.

The occurrence of *Arenicola assimilis* in the southern extremity of South America, the Falklands, South Georgia, Kerguelen, and the southern portion of New Zealand supports the view that there was formerly a more extensive antarctic continent. It is noteworthy that the only species of *Arenicola* known from South Africa is *A. loveni* Kinberg,<sup>b</sup> which is widely different from *A. assimilis* in almost every character, a fact which suggests that the antarctic continent was not continuous with the Cape of Good Hope, to which conclusion, as we have already seen, Beddard was inclined to come from a study of the earthworms.

**ARENICOLA CRISTATA** Stimpson.

*Arenicola antillensis* LÜTKEN.

Seventeen chætigerous segments; eleven pairs of gills, the first situated on the seventh segment; gills large, pinnate, their axes generally joined basally by a web-like membrane; the median lobe of the prostomium (fig. 9)

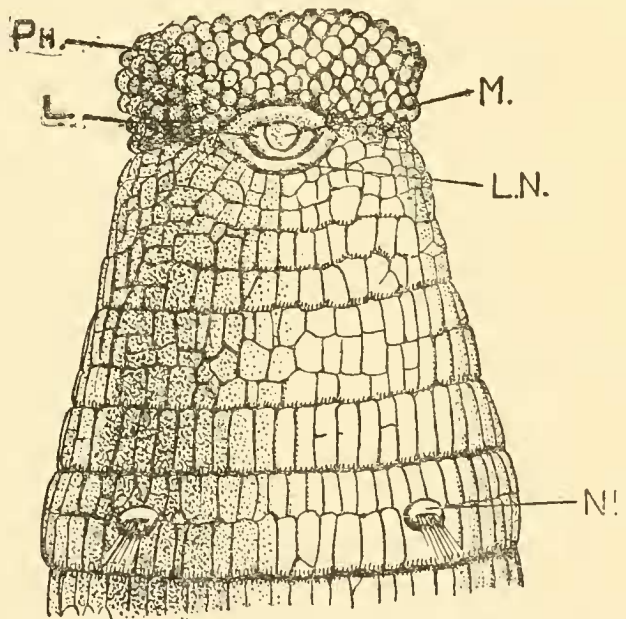


FIG. 9.—*A. CRISTATA*, ANTERIOR END, DORSAL ASPECT, OF A SPECIMEN FROM FLORIDA.  $\times 4$ . *L*, LATERAL LOBE OF PROSTOMIUM; *L. N.*, LIP OF NUCHAL ORGAN; *M*, MEDIAN LOBE OF PROSTOMIUM; *N*<sup>1</sup>, FIRST NOTOPODIUM; *PH*, PHARYNX.

<sup>a</sup> F. E. Beddard. A Monograph of the Order of Oligochæta. Oxford, 1895, p. 154. See also, by the same author, A Text-book of Zoogeography. Cambridge, 1895, pp. 60, 170.

<sup>b</sup> This species, the anatomy and characters of which have not been described, is at present under investigation by the writer.

larger than the lateral ones; the neuropodia of the first few segments are very small, in fact, it is often impossible to see them on the first three segments and that of the fourth segment is a very short slit, the neuropodia of the posterior branchial region are long dorso-ventrally, they and their grooves reach almost to the mid-ventral line; six pairs of nephridia which open on the fifth to the tenth segments; one pair of œsophageal glands, conical, cylindrical, or clavate and comparatively short; a pair of well-developed, muscular finger-shaped pouches projecting backward from the first septum; a pair of statocysts, closed, spherical or ovoid sacs, each containing a single, large, secreted, statolith.

This species has been recorded from the following stations on the American coast:

*A. cristata*, Woods Hole, Massachusetts. C. M. CHILD, Arch. Entwicklungsmech, vol. 9, 1900, p. 587.

*A. cristata*, Woods Hole, Massachusetts. R. S. LILLIE, Mitth. Zool. Stat. Neapel, vol. 17, 1905, p. 344.

*A. cristata*, North Falmouth, Massachusetts. C. M. CHILD, Arch. Entwicklungsmech, vol. 9, 1900, p. 587.

*A. cristata*, New Jersey. H. E. WEBSTER, 32d Ann. Rept. New York State Museum, p. 117, Albany, 1879.

*A. cristata*, Anglesea, New Jersey. J. E. IVES, Proc. Acad. Nat. Sci. Phila. for 1890, p. 73, Philadelphia, 1891.

*A. cristata*, Beaufort, North Carolina. E. A. ANDREWS, Proc. U. S. Nat. Mus., vol 14, p. 289, Washington, 1892.

*A. cristata*, Charleston Harbor, South Carolina. W. STIMPSON, Proc. Boston Soc. Nat. Hist., vol. 5, 1856, p. 114.

*A. antillensis*, Florida, Captiva Key, Florida. E. EHLERS, Mem. Mus. Comp. Zoöl. Harvard, vol. 15, 1887, p. 173.

*A. cristata*, Captiva Key, Florida. F. W. GAMBLE and J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 423.

*A. cristata*, Manatee River, Florida. J. E. IVES, Proc. Acad. Nat. Sci., Phila. for 1890, p. 74, Philadelphia, 1891.

*A. cristata*, Bermuda. H. E. WEBSTER, Bull. U. S. Nat. Mus., No. 25, p. 523, Washington, 1884.

*A. cristata* Bermuda. A. E. VERRILL, Trans. Conn. Acad. Arts and Sci., vol. 10, pt. 2, 1900, p. 599; vol. 11, 1902, p. 39; vol. 12, 1907, p. 147.

*A. cristata*, Bluefields, Jamaica. F. W. GAMBLE and J. H. ASHWORTH, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 423.

*A. antillensis*, St. Croix (Santa Cruz). C. LÜTKEN, Vid. Medd. Naturh. For. Kjöbenhavn, Aaret 1864, 1865, p. 121.

This is one of the most readily recognized species of *Arenicola* by reason of its seventeen chætigerous segments, eleven pairs of large gills, and the beautifully pinnate character of the gills which is so marked a feature of most of the specimens. The character of the gills of Lütken's specimens was so striking that he held it to be a sufficient basis for the delimitation of a new subgenus for which he proposed the name *Pteroscolex*.

I have recently examined specimens from the stations given below; to those in the Smithsonian collection the register numbers are affixed:

Beaufort, North Carolina. [149, 4861, 42896.]

Florida. [211.]

Key West, Florida. [4531.]

Pensacola, Florida. [27229.]

Bermuda. [34478.]

Curaçao. [3798.]

San Pedro, California.

Monterey Bay, California.

The specimen recorded from Pensacola, Florida, extends the distribution of this species westward along the coast of Florida to its extreme western limit. The one from Curaçao is the first example to be recorded from the coast of South America. Of special interest is the finding of this species on the western seaboard of America, which greatly extends its known range, for this species has hitherto been found only at Naples, on the eastern coast of the United States from Woods Hole southward, in Bermuda, and in the West Indies. In one of the specimens from San Pedro there is a small gill on the right side of the sixth segment. This is the only specimen of *Arenicola*, out of thousands examined, in which I have seen a gill on the sixth segment.

*Arenicola cristata* is a giant among Polychæta. One of the examples from Beaufort has a length of 385 mm. (of which the tail forms 115 mm.) and the specimen from Pensacola reaches a length of 460 mm. (of which the incomplete tail forms 80 mm.) and its girth at the sixth segment is about 60 mm. The largest example of this species which I have had is one from Woods Hole, which attains the great length of 515 mm. (of which the tail is 190 mm.) and a girth of 75 mm.

In this, as in other caudate species of *Arenicola*, the tail is obscurely segmented, at segmental intervals there is a larger annulus and upon this, in most American examples, there are, on the ventro-lateral or lateral region, hollow outgrowths of the body wall usually in the form of thumb-shaped processes. The processes at the base of the tail, i. e., in the first tail segment, are usually the largest, and occasionally one of them, generally the most dorsal one, is branched at its distal end, resembling a small gill; this branched process corresponds in position, and seems to be serially homologous, with the gills on the preceding segments. Neapolitan examples of this species do not possess these long caudal processes; slightly larger epidermal papillæ are present on the larger annulus of each tail segment, but they are of the same order as the papillæ of the other annuli.

The type-specimen of *A. cristata* Stimpson is apparently no longer in existence. I have made inquiry for it from the curator of the museum of the Boston Society of Natural History, but I am informed that it is not in that museum; that it was probably in Stimpson's own collection, and, if so, was probably destroyed when the Chicago Academy of Sciences was burned in the great Chicago fire. The specimens on which Lütken based his new species *A. antillensis* are preserved in the Universitets Zoologiske Museum, Kjöbenhavn. I have recently examined two of them. They are typical American specimens of *A. cristata*.

*Summary of the distribution of Arenicola cristata on American shores.*—*A. cristata* is found on the eastern coast of the United States, from Woods Hole, Massachusetts, southward. It extends along the western coast of Florida to Pensacola; it is also recorded from Bermuda, Jamaica, Santa Cruz, and Curaçao, and from two stations, San Pedro and Monterey Bay, on the Californian coast.

*Further distribution.*—Naples, Suez,<sup>a</sup> Barrow Island (northwest Australia),<sup>a</sup> Misaki (Japan).<sup>a</sup>

#### ARENICOLA GLACIALIS Murdoch.

This species was founded to contain specimens of *Arenicola* taken on the International Polar Expedition to Point Barrow, Alaska. Murdoch<sup>b</sup> remarked that the worms in question are closely allied to *A. marina*, but that they have only six setigerous segments anterior to the gills and eleven branchiferous segments, instead of seven and thirteen, respectively, as in *A. marina*. (He should have said six and thirteen, for there are normally six anterior abbranchiate setigerous segments in *A. marina*.) He described each gill as a cluster of about fifteen simple cirri and noted that the tail of each worm, which forms about a third of the length, is without tubercles or other appendages. Five specimens were picked up on the beach on September 12 and 13, 1882, after a fresh westerly gale, and two mutilated ones were obtained from the gullet of an eider duck which had been diving on one of the sandy patches, in about 3 fathoms, just above the station.

There are no figures of this species, and the above constitutes the whole of the information regarding it. Consequently the systematic position of *A. glacialis* with regard to other species is in doubt, and indeed its validity as a species has been questioned. In the number of its anterior abbranchiate segments and of its branchiferous segments this species agrees with *A. cristata*, and on this ground some

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<sup>a</sup> Unpublished records from the manuscript of the present writer.

<sup>b</sup> Report Intern. Polar Exped. to Point Barrow, Alaska, p. 155, Washington, 1885; also in Proc. U. S. Nat. Mus., vol. 7, p. 522, Washington, 1885.



writers<sup>a</sup> have considered *A. glacialis* to be a synonym of *A. cristata*. Von Marenzeller,<sup>b</sup> however, places it under *A. marina*.

The specimens, which are in the collection of the Smithsonian Institution, are now in a very fragile condition; only one of them is complete, another is in two parts, held together by a strand of muscle, and the other three are fragmentary. I have made as complete an examination of these worms as is possible in their present condition, and having regard to their value as types. The inspection of the internal organs was made on one of the imperfect examples (No. 3 in the list below), which consists of the anterior end as far back as the seventh chætigerous annulus and was almost dropping to pieces.

The examination of the specimens shows that *A. glacialis* is a distinct and valid species. As Murdoch's description is totally inadequate, I propose to give an account of the species as far as I have been able to investigate it on the material at my disposal.

The material consists of:

1. A complete specimen 90 mm. long, of which the tail, which is strongly contracted, forms 11 mm.
2. A specimen 105 mm. long, of which the tail forms 45 mm. This specimen is broken, about the ninth segment, into two pieces, held together by a strand of muscle.
3. A portion of an anterior region, 26 mm. long, as far back as the seventh chætigerous annulus.
4. A portion of an anterior region, 14 mm. long, as far back as the third chætigerous annulus.
5. A fragment similar to No. 4, 12 mm. long.
6. A posterior region, consisting of eleven segments and tail, belonging to either No. 4 or No. 5.
7. A posterior region, consisting of eight segments and tail.
8. A branchial region.
9. A portion of a tail.

All the specimens are dark brown to nearly black in color.

Each of the specimens, No. 1 and No. 2, possesses seventeen chætigerous segments, the last eleven of which are provided with gills. It is evident, from an examination of all the specimens, that the gills of this species are small. The axes of the largest gills are not more than 2 mm. in length, measured from their origins to the tips of their terminal gill filaments. The first gill may be very small, as in specimen No. 2, and the last gill is smaller than the preceding ones.

<sup>a</sup> P. Fauvel, Mem. Soc. Nation. Sci. Nat. Math. Cherbourg, vol. 31, 1899, pp. 169, 171. F. W. Gamble and J. H. Ashworth, Quart. Journ. Micr. Sci., vol. 43, 1900, p. 428.

<sup>b</sup> Zool. Jahrb. Abth. Syst., vol. 3, 1888, p. 15.

The gills are best studied in No. 8. The most fully expanded gill of this specimen is shown in fig. 10. It consists of nine or ten axes, which arise from a short, curved, common basal structure situated immediately posterior to the notopodium. The largest axis (see fig. 10, C) bears five branches, each of which divides once, i. e., forks. The longest of the resultant gill filaments are thumb or finger shaped

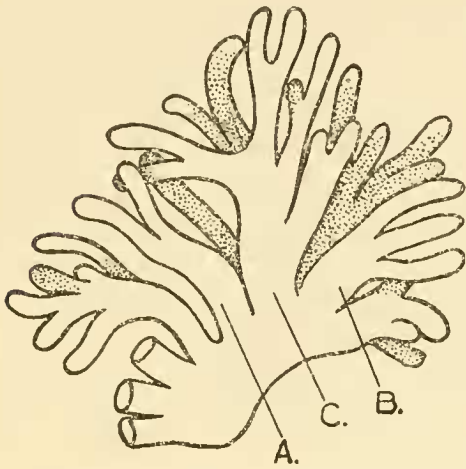


FIG. 10.—A. *GLACIALIS*, NINTH GILL OF NO. 8. THREE OF THE AXES ARE CUT OFF.  $\times 15$ .

structures, not more than about 0.7 mm. in length, and the shortest are mere tubercles. This axis, measured from its origin to the tip of the filaments, is 2 mm. in length. The smaller axes of this gill bear fewer branches, only two or three, and these may be simple, i. e., undivided, distally (see fig. 10, A, B). Another gill, from fragment No. 6, and one of the most fully expanded gills present in the whole of the specimens, is shown in fig. 11. This gill is smaller than the one just described. It is composed of seven axes, the longest and largest

of which (A) bears three branches, each of which bifurcates, and one of the two so formed again divides, but the other does not. In this way three groups, each of three gill filaments, are clustered at the end of the axis. From the base of this axis to the tip of its filaments is a distance of about 1 mm. In all the gills examined the branches of the gill axis are not given off right and left, but are clustered at the end of the axis, so that each axis and its branches look almost like a hand and fingers (see, for instance, figs. 10, 11, B). This character distinguishes the gills of *A. glacialis* from those of any other species, and especially from those of *A. cristata*, the only other species in which there are

eleven pairs of gills, for in *A. cristata* the branches borne on the gill axes are much more numerous and are regularly arranged along the sides of each axis, forming a typically pinnate gill. The gills of *A. glacialis* are also much smaller than those of *A. cristata*. The gill axes of a specimen of the latter 110 mm. long are from 4 to 5 mm. in length, compared with 1 to 2 mm. in examples of *A. glacialis* of about the same size.

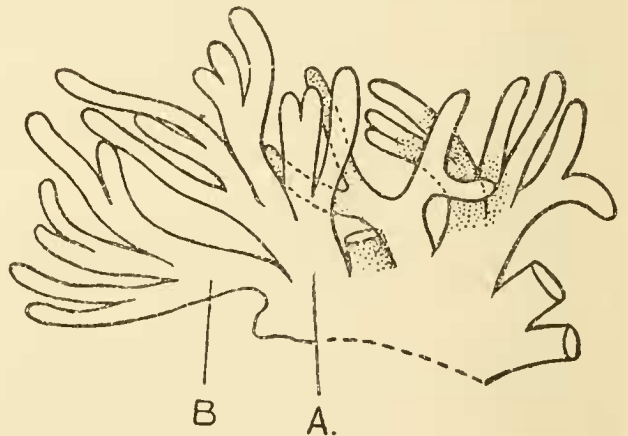


FIG. 11.—A. *GLACIALIS*, THIRD GILL OF NO. 6. THREE OF THE AXES ARE CUT OFF.  $\times 35$ .

eleven pairs of gills, for in *A. cristata* the branches borne on the gill axes are much more numerous and are regularly arranged along the sides of each axis, forming a typically pinnate gill. The gills of *A. glacialis* are also much smaller than those of *A. cristata*. The gill axes of a specimen of the latter 110 mm. long are from 4 to 5 mm. in length, compared with 1 to 2 mm. in examples of *A. glacialis* of about the same size.

The prostomium is well seen in only two of the specimens. It consists (see fig. 12) of two large lateral lobes of almost uniform width (i. e., they are not markedly dilated anteriorly), which unite posteriorly to form a wide median portion of the prostomium. Between the lateral lobes is situated the median one, which is small. Its transverse diameter is less than one-third that of the whole prostomium and its antero-posterior diameter is also short (about .5 mm.). The nuchal organ exhibits the usual relations to the prostomium. In the specimen figured (from No. 5) the lip (L. N.) of the nuchal organ is well everted.

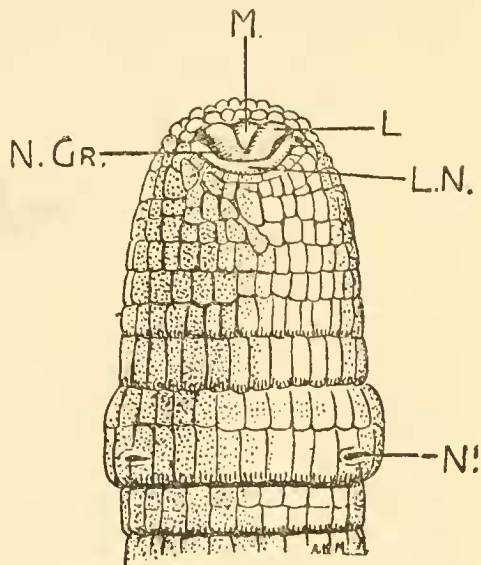


FIG. 12.—A. GLACIALIS, ANTERIOR END, DORSAL ASPECT.  $\times 6$ . L, LATERAL LOBE OF PROSTOMIUM; L. N., LIP OF NUCHAL ORGAN SLIGHTLY EVERTED; M, MEDIAN LOBE OF PROSTOMIUM; N<sup>1</sup>, FIRST NOTOPODIUM (THE NOTOPODIUM IS RETRACTED, LEAVING A SLIT ON THE SURFACE); N. Gr., NUCHAL GROOVE.

The annulation of the anterior region is represented in the annexed diagram (fig. 13), which

is drawn from specimens Nos. 1 and 2. Each segment behind the third is divided into five rings, the largest of which is the chætigerous one.

Neuropodia are clearly visible on each segment, even on the first one. (Compare *A. cristata*.) The groove of the first neuropodium is 0.3 to 0.5 mm. long and five or six erotchetts may be seen in it. The neuropodia gradually increase in length in successive segments; that of the sixth segment is 2.5 mm. in length (in No. 1), and in the branchial region the long muscular ridges of the neuropodia become more obvious. Those of the posterior segments extend from a point just below the notopodium almost to the mid-ventral line and their grooves are about 4.5 mm.

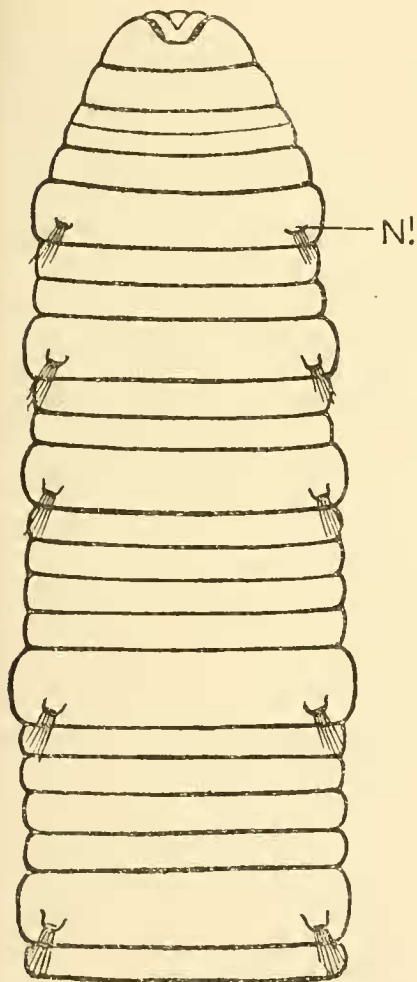


FIG. 13.—A. GLACIALIS, DIAGRAM REPRESENTING THE ANNULATION OF THE ANTERIOR END.  $\times 4$ . N<sup>1</sup>, FIRST NOTOPODIUM.

long. These posterior neuropodia are of the elongate type, seen also in *A. marina* and *A. cristata*, and differ from those of *A. clapedii* and *A. assimilis*, which are shorter and more or less oval cushion-like pads.

The notopodia are simple conical elevations which call for no comment, except that in some of the segments they are retracted, in which case the setæ appear to issue from a slit on the body wall. (See fig. 12, N.<sup>1</sup>)

Specimen No. 1 presents an interesting abnormality. There is, on both sides, an eighteenth neuropodium, about the same size as the seventeenth, but there is no corresponding notopodium or gill. I have met with a similar abnormality in several other species of *Arenicola*, but it is by no means frequent.

The tail, in those specimens in which it is preserved extended, is encircled by pale grooves, which are more strongly marked at segmental intervals. In No. 2 about 22 segments are so indicated; in No. 6, 14 segments; and in No. 7, 21 segments. In No. 1 the tail is contracted and its markings are not clear. The papillæ on the tail are feebly developed and there are no longer processes present such as are found in the tail of *A. cristata*.

*Setæ*.—Most of the notopodial setæ are imperfect, their tips having been broken off, but two or three perfect ones have been examined. These are of the same type as those of *A. marina*; they are about 3.3 mm. long and taper to a fine point and their terminal third bears numerous minute pointed processes closely appressed to the shaft of the seta. No setæ bearing a laminate margin were observed.

Three series of neuropodial crotchets from different specimens (Nos. 3, 6, and 7) have been examined. Most of these crotchets are similar to those of examples of *A. marina* about 70 to 100 mm. in length. The shaft of the crotchet is curved, but not strongly so, and it presents only a slight dilatation near the middle of its length. The distal portion forms a beak-like structure, the "rostrum," bent at an angle of about 130° to the shaft. Immediately proximal to the rostrum, on the convex side of the crotchet, there is occasionally a minute tooth, or sometimes two, to be seen, but in most cases teeth are wanting. Only a few of the crotchets examined have a sub-rostral tooth and when present it is very minute. In most of the crotchets the rostrum is a bluntly conical beak, but in one of the series, which contains the longest crotchets, the rostrum is longer, curved and almost scythe-like in shape (fig. 14, D). This difference is probably attributable to the greater age of these crotchets. The most interesting point observed during the examination of the neuropodial crotchets was in the series from No. 6. At the base of the crotchets in use (fig. 14, B), which are about 0.2 to 0.25 mm. long, there are two much smaller, more strongly curved and only about 0.13 mm. long, so that their tips would not project beyond the lips of the neuropodial groove (fig. 14, A). These small crotchets have a comparatively larger distal region and well-marked teeth are present behind the rostrum. The

characters of crotchets from examples of different ages have been adequately studied only in one species of *Arenicola*, namely, *A. marina*. Judging from the characters of the crotchets from specimens of *A. marina* of different sizes, the two small crotchets above described are such as one would expect to find in a young worm not more than about 20 mm. long. Most of the crotchets of this worm would, after becoming worn, be gradually cast out and replaced by others of a slightly larger size, and this process has no doubt been repeated several times, but for some reason these two crotchets have escaped being cast out and remain among the bases of the crotchets formed at a much later period than they were, for the worm must have been, at the time of capture, about 70 mm. long.

Nephridiopores are visible on the fourth to the ninth segments, inclusive, in specimens Nos. 1 and 2. These apertures have the usual position on the segment, i. e., near the upper end of the neuropodium.

Ova were found escaping through a rupture in the body wall of specimen No. 1. The diameter of these ova is nearly 0.2 mm.

In two specimens the pharynx ("proboscis") is protruded; it is covered with papillæ. Those of the region first everted are conical in form. Those of the portion everted later are much smaller and rounded at their tip.

The internal organs of fragment No. 3 have been examined, but they are very badly preserved, and therefore only a general description of them can be given.

The alimentary canal presents the usual regions—pharynx, œsophagus, and stomach. There is a single pair of œsophageal glands; each gland is somewhat conical in form and about 5.5 mm. long.

Projecting backwards from the first septum, ventro-lateral to the point at which the œsophagus pierces it, there are two thumb-shaped pouches, 2.0 and 2.5 mm. long, respectively.

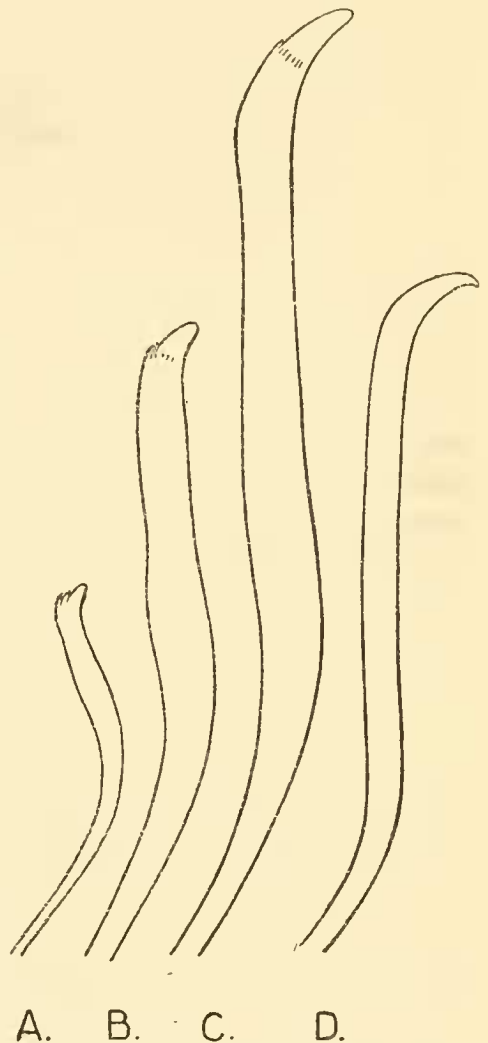


FIG. 14.—A. GLACIALIS, NEUROPODIAL CROTCHETS. A AND B WERE FOUND TOGETHER, THE CROTCHET B WAS IN USE, A IS ONE OF THE TWO SMALL CROTCHETS FOUND IN THIS NEUROPODIUM. FOR FURTHER REMARKS ON THESE, SEE TEXT. A AND B ARE FROM NO. 6,  $\times 300$ , C FROM NO. 7,  $\times 300$ , D FROM NO. 3,  $\times 150$ .

The nephridia are apparently of the same type as those of *A. marina*. The dorsal lip of the second one bears eight flattened processes, rounded at their margins.

A brain and nerve cord are apparently similar to those of *A. marina*, but a detailed examination of them is precluded. Sections of the nerve cord demonstrate the presence of giant nerve cells and giant nerve fibers, such as are found in the cord of all species of *Arenicola* except *A. claparedii*.

Statocysts are present. A small piece of the wall of the peristomium and the statocyst situated upon it were cut into serial sections, the examination of which shows that the statocyst is a pear-shaped vesicle opening to the exterior by a very narrow tube situated in a position corresponding to that of the stalk of the pear. The three diameters of the lumen of the statocyst are 0.144, 0.084, and 0.084 mm., respectively. Its wall is 0.04 to 0.08 mm. in thickness. The statoliths are numerous yellow or colorless sand grains, the largest of which is about  $25\mu$  in diameter. As seen in transverse section, the lumen of the tube, which connects the statocyst to the exterior, is a narrow oval slit, the diameters of which are  $4\mu$  by  $20$  to  $25\mu$ . The statocyst and statoliths are similar to those of *A. marina*, and differ entirely from those of *A. cristata*, which has a closed statocyst containing a single large secreted statolith.

We may now proceed to state the diagnostic characters of

**ARENICOLA GLACIALIS** Murdoch.

Seventeen chætigerous segments; eleven pairs of small gills, the first on the seventh segment; the gill axes are short and their branches are not given off right and left but at or near the distal end of the axis, each branch divides dichotomously once or twice, the resultant finger or thumb shaped gill filaments form clusters at the end of each axis; the median lobe of the prostomium is small, the lateral ones are well developed but are not markedly dilated or lobate at their anterior ends; neuropodia are clearly visible in each segment, those of the posterior branchial segments are long dorso-ventrally and almost reach the mid-ventral line; six pairs of nephridia which open on the fourth to the ninth segments; one pair of conical oesophageal glands; a pair of small pouches projecting backward from the ventral region of the first septum; a pair of statocysts in the peristomium, which open to the exterior; statoliths, numerous, composed of sand grains. Types, the only specimens known, in the Smithsonian Institution, from the beach, Cape Smyth, Alaska, September 12, 1882. [Bottle No. 851.]

*Affinities of Arenicola glacialis.*—The affinities of this species with other caudate species of *Arenicola* may now be determined. There are really no points of agreement between this species and *A. claparedii*. Only two features are common to *A. glacialis* and *A. assimilis*, namely, the number of nephridia and the open statocysts, but these are greatly overbalanced by weighty differences in the number of segments, the number of segments bearing gills, the nature of the

gills, of the neuropodia and especially of the œsophageal glands; we may therefore conclude that the Alaskan species has little affinity with the antarctic one. *A. glacialis* agrees with *A. marina* in the number of its nephridia, its neuropodia, œsophageal glands, septal pouches, statocysts, and statoliths, but differences are noticeable in regard to the number of chætigerous segments and pairs of gills and in the character of the gills, though the gills of *A. glacialis* may almost be regarded as an extreme form of the bushy type of gill seen in many specimens of *A. marina*. *A. glacialis* and *A. cristata* agree in the number of their segments and pairs of gills and in the character of the neuropodia in their branchial region, but they differ in respect of the size and type of their gills, the number and situation of their nephridia, the nature of their septal pouches, statocysts, and statoliths. The systematic position of the species may be stated thus: *A. glacialis* presents no affinity with *A. claparedii* and is so slightly related to *A. assimilis* that the relationship may be neglected; it presents externally some resemblance to *A. cristata*, having the same number of segments and gills, but its internal organs are very like those of *A. marina* and in the form of its prostomium and the character of its gills it is more like *A. marina* than any other species. *A. glacialis* is related to *A. cristata* and *A. marina*, but much more closely to the latter than to the former.

#### THE DIFFERENT REGIONS OF THE AMERICAN SEABOARD AND THEIR SPECIES OF ARENICOLA.

##### 1. East coast of North America:

*Arenicola marina* has been taken at numerous stations on this coast from Rigolet, Labrador, to Noank, Connecticut. The southern limit of this species is probably about 40° N.

*Arenicola cristata* extends from Woods Hole southward to Florida, and is also known from Bermuda.

##### 2. Gulf of Mexico, West Indies, Carribbean Sea:

*Arenicola cristata* is the only species known from this region; it is recorded from Florida, Jamaica, Santa Cruz, and Curaçao.

##### 3. East coast of South America as far south as lat. 51° S.:

There are no records whatever from this portion of the coast.

##### 4. North coast of North America:

*Arenicola glacialis* is recorded from Port Barrow, Alaska. This is the only record of *Arenicola* from the arctic shores of America.<sup>a</sup>

##### 5. West coast of North and South America as far south as lat. 51° S.:

*Arenicola claparedii* is recorded from several stations on this coast, namely, the Aleutian Islands (Amchitka, Atka, Unalaska), Vancouver Island, San Juan Island, Puget Sound, California, Coquimbo, and Puerto Montt (Chile).

*Arenicola cristata* is now recorded from two stations on the Californian coast, namely, Monterey Bay and San Pedro.

##### 6. Southern extremity of South America, south of lat. 51° S.:

*Arenicola assimilis* and the variety *affinis* are the only forms known from this region. *A. assimilis* is known from the Strait of Magellan, the Beagle Channel, and South Georgia. The variety *affinis* is recorded from the Strait of Magellan, the Beagle Channel, and the Falkland Islands.

<sup>a</sup>*Arenicola* is recorded from Greenland, which I have not included as American. All the known specimens from Greenland are *A. marina*.

## KEY TO THE AMERICAN SPECIES OF ARENICOLA.

1. Seventeen chætigerous segments, 11 pairs of gills ..... 2  
Nineteen or twenty chætigerous segments, 13 (or 12) pairs of gills ..... 3
2. Gills large, pinnate; nephridia open on fifth to tenth segments; septal pouches large; statocysts closed, each containing one large statolith.....*cristata*.  
Gills small, bushy; nephridia open on fourth to ninth segments; septal pouches small; statocysts open, each containing numerous statoliths (sand grains).*glacialis*.
3. Neuropodia of posterior branchial region long, their grooves extending almost to the mid-ventral line; one pair of œsophageal glands; a pair of small septal pouches; statocysts open, each containing numerous statoliths (sand grains) .....*marina*.  
Neuropodia of posterior branchial region short, forming pads on the sides of the segments, their grooves not nearly reaching to the mid-ventral line; several pairs of œsophageal glands; no septal pouches ..... 4
4. Twenty chætigerous segments; nephridia open on fourth to ninth segments; large open statocysts each containing numerous statoliths.....*assimilis*.  
Nineteen chætigerous segments ..... 5
5. Lateral lobes of prostomium of moderate size, not folded anteriorly; nephridia open on fourth to ninth segments; open statocysts each containing numerous statoliths.....*assimilis*, var. *affinis*.  
Lateral lobes of prostomium very large, generally folded at their anterior end, nephridia open on fifth to ninth <sup>a</sup> segments, no statocysts.....*claparedii*.

In drawing up this key the character of the prostomium has been used as little as possible, because in many preserved specimens the prostomium is either retracted or its lobes have undergone alteration of shape, owing to their having been in contact with the walls of the vessel in which the specimens have been kept.

Considerable care is necessary in discriminating between *A. claparedii* and *A. assimilis*, var. *affinis* (section 5 of the key). If the prostomial lobes of the specimen under observation are not well preserved, the only features by means of which the species can be determined are the number of nephridia and the presence or absence of statocysts. Rarely specimens of *A. claparedii* have an extra nephridium opening on the fourth segment, only three such cases have been seen out of about a hundred examined, so that the number of nephridia is not an absolutely reliable character for diagnostic purposes. The only way<sup>b</sup> of deciding the species in these cases is therefore to examine, in the dissection which will have been already made to ascertain the number of œsophageal glands and the absence of septal pouches (section 3 of the key), the inner wall of the peristomium along the first part of the course of the œsophageal connectives; if statocysts are visible the specimen is one of *A. assimilis*, var. *affinis*. Occasionally the statocysts are well imbedded in the musculature, and owing to this and to their small size may escape detection. To definitely prove their absence it is necessary to make serial sections of the anterior end of the specimen, or of that region of the peristomial wall in which one of the statocysts would, if present, be situated. Fortunately, recourse to sections is comparatively seldom necessary for diagnostic purposes.

<sup>a</sup> Rarely on fourth to ninth.

<sup>b</sup> Since writing this I have found that the form of the neuropodial crotchets usually affords help in distinguishing these two species.